MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

EOP 3056 – OPTICAL METROLOGY AND TESTING

(All sections / Groups)

10 MARCH 2020

9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

a) As an engineer who is in charge of an optical quality assurance, you are required to suggest 4 active system and 1 passive system that enable surface quality (roughness, Ra) measurement. For each system (other than the Newton Ring Observation Method), please explain briefly how you could use it for Field of View (FOV) up to 100 mm^2.

[15 marks]

b) In order to design an automated flatness checking system, you are required to conceptualise the design as Figure Q1.

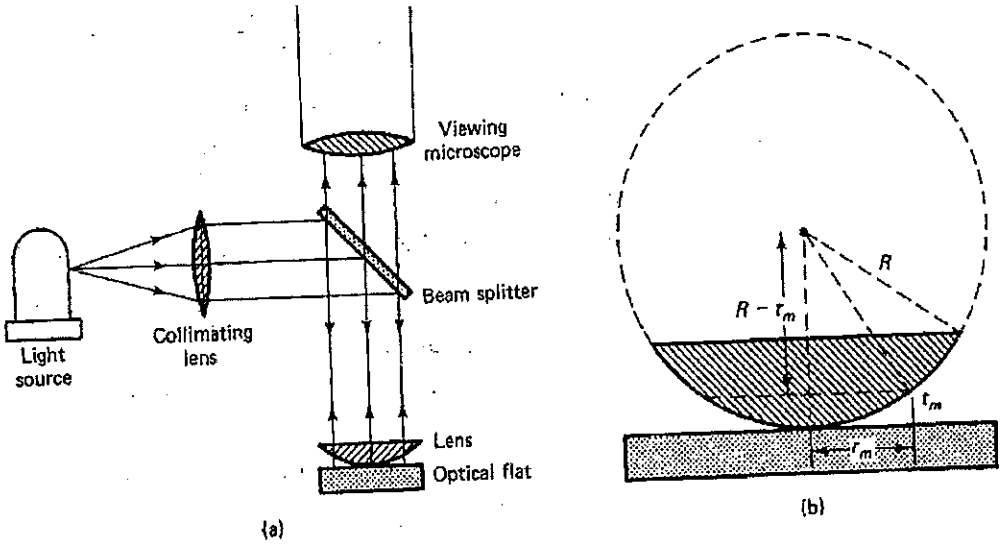

Figure Q1

One of quality measures is the radius R, that derived from the Newton ring observation. Proof that the m^{th} bright ring is

$$r_m^2 = (m+1/2)\lambda R / n_f .$$

[10 marks]

Continued .....

Question 2

As an equipment maker, you are required to examine the fluid temperature variation within a chamber. The design is given with 2 transparent window to view fluid temperature and flow condition. It is observed that the steady state relationship of refractive index, n with temperature, T is:

$$n = T_0 - kT, \qquad k > 0. \qquad \text{Eq. Q2a}$$

a. Suggest a suitable technique to measure the refractive index change. Explain why you choose this technique.

[4 marks]

b. Using a diagram, illustrate the measurement platform you suggested for this measurement.

[4 marks]

c. Given a mono-chromatic light source as:

$$E(x,y,z,t) = Re\{ae^{-i\theta}e^{i\omega t}\}, \qquad \text{Eq. Q2c}$$

where $\theta = 2\pi z/\lambda$. Derive I, the interfered power outcome from 2 identical E interference.

[10 marks]

d. State the assumptions in making the measurement.

[2 marks]

e. Explain using a flow chart, the methodology of finding T, using the measurement.

[5 marks]

Continued .....

Question 3

As a quality assurance engineer, you are required to ensure the quality of a large (3 m in diameter) parabolic mirror. Specifically, the testing and quality evaluation can be digitized using a Shack-Hartmann Wavefront Sensor (SHWS) System (using lenslet array).

a. Using a diagram, explain how the SHWS can be used in the testing and quality assurance. For every slope measurement of the wavefront *S*, describe the phase of the wavefront as a function of the slope measurement (using zonal method).

[12 marks]

b. If the system can be simplified in linear equations form,

$$\vec{y} = A\vec{x};$$

where vector $\vec{y}$ is the slope measurement over M grid points (in one direction over a square grid, m x m = M), vector $\vec{x}$ is the phase of the wavefront over the lenslet surface.

Given the slope measured as below, find the phase of the wavefront. Interpret the results.

$$\vec{y} = \begin{bmatrix} 3 \\ 2 \\ 1 \\ 2 \\ 3 \end{bmatrix}; \qquad A^{-1} = \begin{bmatrix} 0.0195 & 0 & 0 & 0 & 0 \\ 0 & 0.0195 & 0 & 0 & 0 \\ 0 & 0 & 0.0031 & 0 & 0 \\ 0 & 0 & 0 & 0.0031 & 0 \\ 0 & 0 & 0 & 0 & 0.0098 \end{bmatrix}.$$

[6 marks]

c. Suggest a method to enhance the lateral resolution of the system. Explain the methodology using a diagram.

[7 marks]

Continued .....

Question 4

a. Using a diagram, explain how a passive system of your choice (give the name of the system) that can be used to measure 3D range data.

[13 marks]

b. In a passive mode autonomous vehicle 3D ranging system, the engineer is required to enhance the system that allow the vehicle to detect near range (less than 1 meter from the vehicle), and far range (500 meters range object) on the road. The object is at the size of 10cm height.

i. As the engineer, suggest ONE (1) method to modify the system in Q4 (a).

[2 marks]

ii. Describe how is your suggested method can detect it for near range o.

[4 marks]

iii. Describe how is your suggested method can detect it for far range object.

[4 marks]

iv. List down your assumptions.

[2 marks]

End of Page